LAKE HOPATCONG
WATER QUALITY MONITORING
ANNUAL REPORT 2006

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Table of Contents

1.0 INTRODUCTION

Princeton Hydro, LLC conducted general water quality monitoring of Lake Hopatcong during the 2006 growing season (May through September). This monitoring program represents a continuation of the long-term monitoring program of Lake Hopatcong. The current water quality monitoring program is a modified version of the program that was originally initiated in the Phase I Diagnostic / Feasibility Study of Lake Hopatcong (PAS, 1983) and continued through the Phase II Implementation Project. Both the Phase I and Phase II projects were funded by the US EPA Clean Lakes (314) Program.

The current water quality monitoring program is valuable in terms of continuing the inter-annual, baseline database of the lake, identifying long-term trends in water quality, and quantifying and objectively assessing the success and potential impacts of restoration efforts. In addition, the in-lake water quality monitoring program will be an important component of evaluating the long-term success of the implementation of the phosphorus TMDL-based Restoration Plan, which was approved by NJDEP in April of 2006.

2.0 MATERIALS AND METHODS

In-lake water quality monitoring was conducted at the following eleven (11) locations in Lake Hopatcong (Figure 1 in Appendix A) during the study period:

Station Number	Location
1	Woodport Bay
2	Mid-Lake
3	Crescent Cove/River Styx
4	Point Pleasant/King Cove
5	Outlet
6	Henderson Cove
7	Inlet from Lake Shawnee
8*	Great Cove
9*	Byram Cove
10	Northern Woodport Bay
11	Jefferson Canals

* *In-situ* monitoring only

The 2006 sampling dates were 15 May, 16 June, 25 July, 22 August and 28 September. A Eureka Amphibian with Manta multi-probe unit was used to monitor the *in-situ* parameters dissolved oxygen (DO), temperature, pH, and conductivity during each sampling event. Data were recorded at 1.0 m increments starting at 0.5 m below the water's surface and continued to within 0.5 m of the lake sediments at each station during each sampling date. In addition, water clarity was measured at each sampling station with a Secchi disk.

Discrete water quality samples were collected with a Van Dorn sampling device at 0.5 m below the lake surface and 0.5 m above the sediments at the mid-lake sampling site (Station #2). Discrete samples were collected from a mid-depth position at the remaining six (6) original sampling stations (Stations #1, 3, 4, 5, 6 and 7) and additionally at the Northern Woodport Bay and Jefferson Canals site (Stations #10 and #11, respectively) on each date. Discrete water samples were appropriately preserved, stored on ice, and transported to a State-certified laboratory for the analysis of the following parameters:

- total suspended solids
- total phosphorous-P
- nitrate-N
- ammonia-N
- chlorophyll *a*

All laboratory analyses were performed in accordance with *Standard Methods for the Examination of Water and Wastewater, 18th Edition* (American Public Health Association, 1992). Monitoring at the Great Cove (Station #8) and Byram Cove (Station #9) sampling stations consisted of collecting *in-situ* and Secchi disk data; no discrete water samples were collected from these two stations for laboratory analyses. It should be noted that prior to 2005, Station #10 had been monitored for *in-situ* observations only. However, due to recent observations made at Station #10 by the Lake Hopatcong Commission operations staff, it was decided that this sampling station should be added to the discrete sampling list.

During each sampling event, vertical plankton tows were also conducted at the deep sampling station (Station #2). A 50-µm mesh plankton net was used to sample the phytoplankton, while a 150-µm mesh plankton net was used to sample the zooplankton. The vertical tows were deployed starting immediately above the anoxic zone (DO concentrations < 1 mg/L) and conducted through the water column to the surface.

Additional Water Quality Data Collected in 2006

In addition to the standard, long-term, in-lake monitoring program, additional data were collected in the Lake Hopatcong watershed in the later half of 2006. These data were collected for various reasons including refining the lake's phosphorus TMDL, obtaining a better understanding of the baseflow and storm event pollutant loads entering Lake Hopatcong and developing a water quality data to assess the pollutant removal capacity of the structural BMPs that will be installed as part of the existing Non-Point Source (319(h)) grant.

Baseline Tributary Monitoring Program

In 2006 the Lake Hopatcong Commission received approval from NJDEP through a Quality Assurance Protection Plan (QAPP) to be trained on the collection of baseline (non-storm event) water quality samples from tributaries that drain into Lake Hopatcong. Princeton Hydro trained the operations staff to collect baseline water samples from three selected tributary sampling locations:

1. Jaynes Brook, enters Henderson Cove, along the boarder of the Township of Jefferson and the Borough of Hopatcong.
2. Quarry Brook, enters a small cove just west of the Woodport Cove, within the Township of Jefferson.
3. Great Cove Brook, enters Great Cove within the Township of Jefferson.

Four baseline sampling events were conducted of these three tributary stations between September and November 2006. For the sake of this study, baseline was defined as no measurable (< 0.1 inches) amount of precipitation 72 hours prior to the sampling event. The collected water samples were appropriately preserved, stored and transported to a State-certified laboratory and analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), nitrate-N (NO_3-N) and total suspended solids (TSS). The operations staff was also trained on how to read stream water level with a staff gage and measure water flow with a field instrument.

Stormwater Monitoring Program

As part of the 319(h) grant awarded to the Lake Hopatcong Commission the operations staff was trained by Princeton Hydro to collect composite stormwater samples from locations that have been selected for the installation of specific structural BMPs. Again, a QAPP was developed, submitted to and approved by NJDEP so the resulting data will be accepted by the State.

A total of four stormwater sampling stations were established, each one located at a site where stormwater samples will be collected flowing into and out of an installed structural BMP during post-installation events. However, it should be noted that pre-installation stormwater sampling was conducted as well. The four stormwater sampling sites included:

1. Runoff that flows over and under the Hopatcong Beach Club's parking lot, which drains into Crescent Cove, Borough of Hopatcong.
2. Runoff from the Bell Avenue drainage area that flows over and under Lakeside Boulevard and into Crescent Cove, Borough of Hopatcong.
3. Runoff from a roadside swale along Dupont Avenue, which drains into the southern end of Crescent Cove, Borough of Hopatcong.
4. Runoff flow over and under Castle Rock Road, which then enters Lake Hopatcong in the Township of Jefferson.

A minimum of three pre-installation and three post-installation of the BMPs stormwater sampling events were scheduled to be conducted by the operations staff. Through 2006 a total of four pre-installation stormwater sampling events were conducted from September to December. However, during two of the four storm events, there was not a sufficient amount of runoff flowing through the roadside swale along Dupont Avenue (Station #3) to collect a composited stormwater sample. All stormwater samples were analyzed for TP, TDP, SRP and TSS.

Additional In-Lake Monitoring

In addition to stormwater sampling, the long-term in-lake water quality monitoring program was expanded to include near-shore, in-lake sampling stations at locations immediately adjacent to the drainage area that will receive the structural BMPs. The three near-shore, in-lake sampling stations include:

1. The southern end of Crescent Cove in the Borough of Hopatcong.
2. Ingram Cove, located in the Borough of Hopatcong.
3. Along the eastern shoreline of the lake, in the Township of Jefferson, just south of Brady's Bridge.

It should be noted that originally one of the 319 structural BMPs was planned to be installed in the Ingram Cove drainage area. However, due to site specific limitations associated with existing utilities, it was decided to move the BMP to the Creasing Cove drainage area. However, monitoring of the Ingram Cove sampling station continued through 2006. From May through September 2006, five sampling events were conducted at each 319 in-lake sampling station. Monitoring included collecting *in-situ* data at 0.5 – 1.0 meters from surface to bottom for temperature, dissolved oxygen, pH and conductivity. Water clarity was also measured at each station with a Secchi disk. Discrete mid-depth water samples were collected and analyze for TP and TSS.

3.0 RESULTS AND DISCUSSION

Thermal Stratification

Thermal stratification is a condition where the warmer surface waters (called the epilimnion) are separated from the cooler bottom waters (called the hypolimnion) through differences in density, and hence, temperature. Thermal stratification separates the bottom waters from the surface waters with a layer of water that displays a sharp decline in temperature with depth (called the metalimnion or thermocline). In turn, this separation of the water layers can have a substantial impact on the ecological processes of a lake (for details see below). Thermal stratification tends to be most pronounced in the deeper portions of a lake. Thus, for convenience, the discussion on thermal stratification in Lake Hopatcong focuses primarily on the deep, mid-lake (Station #2) sampling station.

In-situ measurements during the 2006-growing season were generally consistent with values recorded in previous years' monitoring programs. During the 2006 sampling season, the presence of an established thermocline or metalimnion was particularly distinct. This can be attributed to the relatively low frequency of storm events during the 2006-growing season, especially in the late summer months. The minimum number of individual storm events allowed thermal stratification to remain consistently established through the growing season.

On 15 May 2006, Lake Hopatcong was already thermally stratified, demonstrating a very narrow thermocline at a depth between and 7 and 9 meters. From surface to bottom (14 meters), the temperature decreased from 15.9°C at the surface to 10.4^{o}C at the bottom (Appendix B).

By 16 June 2006, thermal stratification was strong and well established at the mid-lake sampling station (Station #2). The epilimnion was located from the surface to 5 meters (16.5 ft). The metalimnion was located between 6 and 8 meters (20 and 26.4 ft), while the hypolimnion began at a depth greater than 9 meters.

During the 26 July 2006 and 22 August 2006 sampling events, the epilimnion was located from the surface to 5.5 meters and 6 meters, respectively. The thermocline was located between 6 and 10 meters, with the hypolimnion being below 7 and 11 meters.

The surface waters of Lake Hopatcong were substantially cooler on 28 September relative to 22 August. The lake was well mixed from the surface to 10 meters, while the thermocline was distributed between 10.5 and 13 meters.

The only monitoring stations that were stratified from May through September were Stations #2 (mid-lake) and #9 (Byram Cove). The other moderately deep sampling station (> 5 meters), Station #8 (Great Cove), was stratified in June and July. The remaining eight (8) sampling stations were well mixed through the entire sampling season. These well-mixed conditions were the result of relatively shallow water depths (< 3 meters) and exposure to winds.

It is interesting to note that the three near-shore in-lake sampling stations that were monitored for the 319 grant were periodically weakly stratified, in spite of being generally less than 3 meters in total depth.

Thermal stratification can effectively "seal off" the bottom waters from the surface water and overlying atmosphere, which can result in a depletion of dissolved oxygen (DO) in the bottom waters. With the exception of a few groups of bacteria, all aquatic organisms require measurable amounts of DO (> 1 mg/L) to exist. Thus, once the bottom waters of a lake are depleted of DO, a condition termed anoxia, that portion of the lake is no longer available as viable habitat.

Dissolved Oxygen

Atmospheric oxygen enters water by diffusion from the atmosphere, facilitated by wind and wave action and as a by-product of photosynthesis. Adequate dissolved oxygen (DO) is necessary for acceptable water quality. Oxygen is a necessary element for most all forms of life. As dissolved oxygen concentrations fall below 5.0 mg/L, aquatic life is put under stress. DO levels that remain below 1.0 – 2.0 mg/L for a few hours can result in large fish kills and loss of other aquatic life. Although some aquatic organisms require a minimum of 1.0 mg/L of DO to survive, the NJDEP State criteria for DO concentrations in surface waters is 5.0 mg/L or greater, for a healthy and diverse aquatic ecosystem.

In addition to a temporary loss of bottom habitat, anoxic conditions (DO < 1 mg/L) can produce chemical reactions that result in a release of phosphorus from the sediments and into the overlying waters. In turn, a storm event can transport this phosphorus to surface waters and stimulate additional algal growth. This process is called internal loading. Given the temporary loss of bottom water habitat and the increase in the internal phosphorus load, anoxic conditions are generally considered undesirable in a lake.

During the 15 May 2006 sampling event, DO concentrations were above the 5.0 mg/L threshold throughout most of Lake Hopatcong. Only the deepest waters (> 12 meters) of Station #2 (mid-Lake) had depressed concentrations of DO (< 4.0 mg/L).

The surface waters of Lake Hopatcong were also generally well oxygenated (> 5.0 mg/L) during the 16 June 2006 sampling event. Anoxic conditions (DO concentrations < 1 mg/L) were identified at depths greater than 13 meters.

During the 26 July 2006 sampling event, Lake Hopatcong was well oxygenated from the surface to a depth of about 5 meters. At the Mid-Lake sampling station, anoxic conditions were identified from 5.5 meters to the bottom of the lake during the late July sampling event. At Station #9 anoxic conditions were measured from 5 meters to the bottom.

During the 22 August 2006 sampling event, from the surface to 7 meters the lake was well oxygenated, while anoxic conditions were measured at depths greater than 9 meters. Typically, anoxic conditions in the bottom waters persist through the summer season in Lake Hopatcong. This condition was intensified in 2006 by the minimum number of storm events during the late summer season. The general lack of large storm events resulted in a minimum amount of mixing through the water column. Such conditions maintain the anoxic conditions in the bottom waters through the growing season by preventing the transfer of oxygenated water to the deeper sections of the lake.

On 28 September 2006, anoxic conditions persisted in sections of Lake Hopatcong greater than 11 meters in depth (Appendix B). In contrast, from the surface to 10 meters, Lake Hopatcong was well oxygenated, with DO concentrations typically being greater than 6.0 mg/L (Appendix B).

The three, 319 near-shore sampling stations were well oxygenated from surface to bottom during the 16 June 2006 sampling event. On 17 July 2006, the Crescent Cove and Ingram Cove near-shore sampling stations were well oxygenated with DO concentration greater than 10 mg/L. These high DO concentrations in mid-July were indicative of elevated rates of algal and/or aquatic plant photosynthesis. In sharp contrast, the near-shore Jefferson sampling station was well oxygenated in the surface waters and anoxic at depths greater than 2 meters. All three 319 near-shore sampling stations were well oxygenated from surface to bottom during the last three monitoring events.

pH

The optimal range of pH for most freshwater organisms is between 6.0 and 9.0. For the most part, the pH throughout the water column of Lake Hopatcong was within this optimal range. The exception was the pH at the River Styx (Station #3) and the Outlet (Station #5) sampling stations during the 15 May 2006 monitoring event, when the pH was greater than 10. Such temporarily elevated pH values in the surface waters can be attributed to high rates of algal and/or aquatic plant photosynthesis. As algae and plants photosynthesize, they produce DO as a by-product, as well as increase the pH of their immediate environment. In spite of these temporarily elevated pH values, the pH of Lake Hopatcong throughout most of the 2006 growing season was within the optimal range for most aquatic organisms.

At the three 319 near-shore sampling stations pH values were generally within the optimal range for most freshwater life. The exception to this was during the 17 July 2006 sampling event when the surface water pH at the Crescent Cove and Ingram Cove sampling stations were greater than 11. Such high pH values, in conjunction with the high DO concentrations, measured at the Crescent Cove and Ingram Cove sampling stations on 17 July 2006, were indicative of high rates of photosynthesis. Large amounts of submerged vegetation and algal mats were observed at both stations during the 17 July 2006 sampling event.

Water Clarity (as measured with a Secchi disk)

Water clarity or transparency, as measured with a Secchi disk, was generally acceptable at all of the sampling stations during the 2006 sampling season. Based on Princeton Hydro's in-house long-term database of lakes in northern New Jersey, water clarity is considered acceptable for recreational activities when the Secchi depth is equal to or greater than 1.0 m (3.3 ft). Secchi depth measurements throughout almost all of Lake Hopatcong were greater than 1.0 meter in 2006. For example, at the mid-lake sampling station (Station #2), the Secchi depth varied from 1.2 to 2.5 meters (4.0 to 8.25 ft) through the course of the 2006 sampling season. The exception to these acceptable water clarity measurements was the Crescent Cove / River Styx (Station #3) sampling station, where Secchi depth fell below the 1.0 meter threshold during the July and August sampling events (Figure 2).

Of the eleven sampling stations, the Crescent Cove / River Styx (Station #3) sampling station historically tends to have the lowest water clarity, particularly in July and August. During these months, Secchi depths are typically below the 1.0 m threshold. Such conditions were certainly observed during the 2006 sampling season. Secchi depths at Station #3 averaged 0.5 meters through July and August in 2005. Over this same time period, TSS (total suspended solids) concentrations were moderate (between 12 and 9 mg/L) relative to high chlorophyll-*a* concentrations (between 48.7 and 58 mg/m^3). These observed conditions indicate that the sub-optimal July and August Secchi depths at Station #3 were primarily due to algal blooms. Annually, Station #3 has the lowest Secchi depths relative to the other sampling stations of the lake; both algal blooms and excessive densities of aquatic plants typically plague this section of the lake during the summer season. Such unacceptable water quality conditions have directed the watershed-based restoration measures to focus on the portion of the Borough of Hopatcong that directly drains into the Crescent Cove / River Styx section of the lake. Thus, three of the four structural BMPs projects that will be installed in 2007 will be placed within the Crescent Cove drainage area.

The 319 near-shore Crescent Cove station's Secchi depth was consistently below the 1.0 meter threshold during all five 2006 sampling events. Again, this section of the lake was selected for the installation of the majority of the structural BMPs due to its low water quality. The Secchi depth at the near-shore Jefferson station was consistently greater than 1.0 meter. With the exception of the 16 June 2006 sampling event, the Ingram Cove near-shore station also had Secchi depths greater than 1.0 meter.

Ammonia-Nitrogen (NH_4-N)

Surface water NH_4-N concentrations above 0.05 mg/L tend to stimulate elevated rates of algal growth. Over the 2006 season, surface water NH_4-N concentrations throughout Lake Hopatcong varied between <0.01 mg/L and 0.07 mg/L. All eight (8) of the stations had NH_4-N concentrations less than the 0.05 mg/L threshold in 2006. The exception to this was at Station 6 (Henderson Cove) during the 22 August event.

Bottom water NH_4-N concentrations are monitored seasonally at the mid-lake sampling site (Station #2). The bottom water NH_4-N concentrations remained below the 0.05 mg/L threshold, except for the 28 September event. Bottom water NH_4-N concentrations are typically elevated during summer months, as a result of a depletion of dissolved oxygen. Under such conditions, bacterial decomposition of organic matter results in an accumulation of NH_4-N. The severe limitation of light in the bottom waters exacerbates these conditions through the negligible uptake of NH_4-N by algae. Thus, this seasonal accumulation of NH_4-N is common occurrence in Lake Hopatcong.

Nitrate-Nitrogen (NO_3-N)

NO_3-N concentrations throughout the 2006 sampling season of Lake Hopatcong varied between <0.02 mg/L and 0.14 mg/L. While there was a considerable amount of variation both among the sampling stations and between sampling events, the NO_3-N concentrations measured in July were considerably lower relative to the June concentrations. Most of the NO_3-N concentrations measured in July were at or below the analytical detection limit of 0.02 mg/L. In contrast, during the June sampling event, the surface water NO_3-N concentrations varied between 0.03 and 0.14 mg/L.

On 28 September 2006, the NO_3-N concentrations at all of the sampling stations were less than or equal to 0.07 mg/L. In 2006, differing from the other water quality parameters, the Station 11 (Jefferson Canals) sampling station consistently had the highest NO_3-N concentrations.

Total Phosphorous (TP)

Phosphorus has been identified as the primary limiting nutrient for algae and aquatic plants in Lake Hopatcong. Essentially, a small increase in the phosphorus load will result in a substantial increase in algal and aquatic plant growth. For example, one pound of phosphorus can generate as much as 1,100 lbs of wet algae biomass. This fact emphasizes the continued need to reduce the annual phosphorus load entering Lake Hopatcong.

Studies have shown that TP concentrations as low as 0.03 mg/L can stimulate high rates of algal growth resulting in eutrophic or highly productive conditions. Based on Princeton Hydro's in-house database on northern New Jersey lakes, TP concentrations equal to or greater than 0.06 mg/L will typically result in the development of algal blooms / mats that are perceived as a nuisance by the layperson.

The State's Surface Water Quality Standard (SWQS, N.J.A.C. 7:9B – 1.14(c) 5) for TP in the surface waters of a freshwater lake or impoundment is 0.05 mg/L. This established TP concentration is for any freshwater lake or impoundment in New Jersey that does not have an established TMDL. Lake Hopatcong has an established phosphorus TMDL, which was revised and approved by NJDEP in June 2006. Based on its refined phosphorus TMDL, the long-term management goal is to maintain a average, growing season TP concentration of 0.03 mg/L within the surface waters of Lake Hopatcong.

During the 15 May sampling event, TP concentrations throughout the lake generally varied between 0.03 mg/L and 0.08 mg/L. The lake at this time had a greenish hue, which was more than likely the result of a moderate spring algal bloom (see Section on phytoplankton for details).

Spring storm events transport phosphorus from the watershed to the lake, resulting in spring algal blooms.

During the 16 June 2006 sampling event, TP concentrations throughout Lake Hopatcong varied between 0.01 mg/L and 0.05 mg/L. Surface water TP concentrations during the 25 July 2006 sampling event were slightly higher when compared to June. During the July 2006 sampling event, the highest TP concentration was at Station #3 (River Styx / Crescent Cove), 0.08 mg/L, above the State's water quality standard.

During the 22 August 2006 sampling event, TP concentrations in the surface waters were substantially lower relative to earlier sampling events, generally varying between <0.01 mg/L and 0.03 mg/L. Finally, during the 28 September 2006 sampling event, surface water TP concentrations again varied between <0.01 mg/L and 0.02 mg/L.

In general, TP concentrations in Lake Hopatcong were slightly elevated in the spring, highest in mid-summer and generally lower through the late summer. The highest concentrations of TP occurred at Station #3 (River Styx/Crescent Cove). As previously identified such elevated TP concentrations in this section of the lake is a re-occurring condition. The elevated summer TP concentrations at Station #3 are the result of the land use activities within the surrounding sub-watersheds (Borough of Hopatcong), as well as the minimal amount of hydrologic flushing. Combined, these factors provide the opportunity for algae and aquatic plants to assimilate available phosphorus and produce the nuisance in-lake conditions typically observed in the Crescent Cove / River Styx portion of the lake. Again, this is why this section of the watershed was targeted for the implementation of most of the structural BMPs, funded through the 319 grant.

Unlike previous monitoring years, the TP concentrations at the mid-lake, deep sampling station (Station #2) were minimal in mid-summer, consistently at 0.02 mg/L, until the 28 September monitoring event, when the concentration attained 0.39 mg/L. (Appendix C). Such an elevated TP concentration in the deep waters are attributed to the establishment of anoxic conditions (DO < 1 mg/L) during the mid to late summer months. The accumulation of such high TP concentrations in the bottom waters were attributed to the minimal number of storms experienced in the late summer of 2006.

Dry growing seasons tend to strengthen the density difference between the epilimnion and hypolimnion and impede the transport of deep water TP to the surface. This allows for an accumulation of phosphorus in the bottom waters. In contrast, growing seasons that experience large and frequent storm events, such as 2003 and 2004, tend to have weakened thermal stratification, allowing for the transfer of deeper waters to the surface. In turn, bottom water TP concentrations tend to be lower relative to the bottom water in dry growing seasons. However, this transfer of bottom water TP during "wet" years can fuel the development of algal blooms and surface scums.

Chlorophyll a

Chlorophyll *a* is a pigment possessed by all algal groups, used in the process of photosynthesis. Its measurement is an excellent means of quantifying algal biomass. In general, an algal bloom is typically perceived as a problem by the layperson when chlorophyll *a* concentrations are equal to or greater than 30.0 mg/m^3. Based on the findings of the refined TMDL, the existing average seasonal chlorophyll *a* concentration under existing conditions is 15 mg/m^3, while the maximum seasonal value is 26 mg/m^3. In contrast, the targeted average and maximum chlorophyll *a* concentrations, once Lake Hopatcong is in complete compliance with the TMDL, are predicted to be 8 and 14 mg/m^3, respectively.

The average chlorophyll *a* concentrations for May, June and September 2006 were below the existing mean concentration of 15 mg/m^3. In contrast, the July and August 2006 mean chlorophyll *a* concentrations were 19.7 and 16.1 mg/m^3, respectively, greater than the existing mean of 15 mg/m^3 but less than the existing maximum seasonal value. In addition, the July and August 2006 chlorophyll *a* concentrations at Station #3 exceeded the maximum seasonal value of 26 mg/m^3. These elevated chlorophyll *a* concentrations in July and August indicate that algal blooms were experienced within specific sections of Lake Hopatcong during the mid-summer season. While the majority of the 2006 concentrations did not attain the 30 mg/m^3 threshold, the measured concentrations in conjunction with some select shoreline observations made during the summer season (for details see below), were indicative of nuisance conditions. These results indicate that efforts must continue in complying with the targeted TP and chlorophyll *a* concentrations for Lake Hopatcong, as established in its TMDL.

Phytoplankton

Phytoplankton are algae that are freely floating in the open waters of a lake or pond. These algae are vital to supporting a healthy ecosystem, since they are the base of the aquatic food web. However, high densities of phytoplankton can produce nuisance conditions. The majority of nuisance algal blooms in freshwater ecosystems is the result of cyanobacteria, also known as blue-green algae. Some of the more common water quality problems created by blue-green algae include bright green surface scums, taste and odor problems and cyanotoxins.

Table 1 lists the dominant phytoplankton identified in Lake Hopatcong during each water quality monitoring event in 2006. A bloom of the diatom *Fragilaria* and the chrysophyte *Dinobryon* was identified on the 15 May 2006 sampling date. Both algal groups tend to bloom in the spring and can give the water a brown, turbid appearance. A variety of other diatoms, the green alga *Oocystis* and the dinoflagellate *Ceratium* were also identified in the May 2006 sample (Table 1).

The diatom *Fragilaria* remained the dominant algal in Lake Hopatcong during the mid-June 2006 sampling event. The chrysophyte *Dinobryon*, several diatoms and a variety of green algae were also identified in the 16 June 2006 sample. The major difference between the May and June 2006 phytoplankton samples in Lake Hopatcong was that four blue-green algae were identified in the June 2006 sample and included *Coelosphaerium, Oscillatoria*, *Microcystis* and *Anabaena*. In spite of the presence of these potentially nuisance genera, June 2006 chlorophyll *a* concentrations throughout the lake varied between 3.5 and 14 mg/m^3, below the recreational nuisance threshold of 30 mg/m^3.

By 25 July 2006 the blue-green algae *Anabaena* and *Coelosphaerium* were the dominant algal group in Lake Hopatcong. Two other blue-green algae, *Microcystis* and *Oscillatoria*, were also identified in the lake at this time. A variety of green algae, several diatoms and two genera of dinoflagellates were also identified.

Total algal densities were relatively high in Lake Hopatcong on 22 August 2006. The dominant alga at this time was the filamentous blue-green alga *Oscillatoria*. Three other genera of blue-green algae, *Microcystis*, *Anabaena* and *Coelosphaerium*, were identified in Lake Hopatcong at this time. Several genera of green algae, the diatom *Melosira* and the chrysophyte *Dinobryon* were also identified in the lake.

By 28 September 2006 the dominant algal group shifted from the blue-green algae, back to the diatoms. Specially, the filamentous diatom *Melosira* was the dominant genus in Lake Hopatcong at this time. A variety of other diatoms and algae were identified in the late September 2006 sample (Table 1). Three blue-green algae, *Microcystis*, *Anabaena* and *Oscillatoria*, were also identified in the sample.

Table 1
Phytoplankton in Lake Hopatcong during the 2006 Growing Season

Sampling Date	Phytoplankton
15 May 2006	The dominant algae were the diatom *Fragilaria* and the chrysophyte *Dinobryon*. A variety of diatoms (*Synedra*, *Melosira*, *Asterionella*, *Tabellaria*), the green alga *Oocystis* and the dinoflagellate *Ceratium* were also identified.
16 June 2006	The dominant alga was the diatom *Fragilaria*. Other diatoms (*Melosira*, *Asterionella*) and green algae (*Pediastrum*, *Gloeocystis*, *Dictyosphaerium*, *Chlorella*) and were identified in the June sample. A chrysophyte (*Dinobryon*), and four genera of blue-green algae (*Coelosphaerium*, *Microcystis, Anabaena* and *Oscillatoria*) were also identified in the sample.
25 July 2006	The dominant algae were the blue-green algae *Anabaena* and *Coelosphaerium*. Other blue-green were identified and included *Microcystis* and *Oscillatoria.* The sample also included a variety of green algae (*Pediastrum*, *Gloeocystis*, *Pandorina*, *Chlorella, Staurastrum*), several diatoms (*Melosira*, *Fragilaria*) and several dinoflagellates (*Ceratium, Peridinium*).
22 August 2006	Phytoplankton abundance was high with the dominant alga was the blue-green *Oscillatoria*. Other blue-green algae were identified and included *Coelosphaerium*, *Microcystis* and *Anabaena*. Several green algae (*Pediastrum*, *Rhizoclonium*, *Staurastrum*) the diatom *Melosira* and the chrysophyte *Dinobryon* were identified in the sample.
28 September 2006	The dominant alga was the diatom *Melosira*. Other diatoms (*Tabellaria*, *Fragilaria*, *Stephanodiscus, Synedra*), a chrysophyte (*Dinobryon*), a dinoflagellate (*Ceratium*) a green alga (*Staurastrum*), and several blue-green algae (*Anabaena*, *Microcystis*, *Oscillatoria*) were also identified in the sample.

Zooplankton

Zooplankton are the micro-animals that live in the open waters of a lake or pond. Some large-bodied zooplankton are a source of food for forage and/or young gamefish. In addition, many of these large-bodied zooplankton are also herbivorous (i.e. algae eating) and can function as a natural means of controlling excessive algal biomass. Given the important role zooplankton serve in the aquatic food web of lakes and ponds, samples for these organisms were collected at Station #2 during each monitoring event. The results of these samples are provided in Table 2.

Similar to past monitoring years, the zooplankton community of Lake Hopatcong was dominated by small-bodied cladocerans such as *Bosmina*, several genera of rotifers and/or predaceous copepods such as *Cyclops* through the course of the 2006 monitoring season. These types of zooplankton tend to feed on bacteria, detritus and in some cases other zooplankton. None of the dominant zooplankton were large, highly herbivores; that is, algae is not their primary source of food.

While herbivorous zooplankton were not common in Lake Hopatcong, three herbivorous genera were identified through the 2006 sampling season, which included the cladocerans *Daphnia* and *Ceriodaphnia* and the copepod *Diaptomus* (Table 2). Of these zooplankton, *Daphnia* is the most efficient herbivore; this is primarily due to its potential to attain large lengths (up to 2 mm) and its particular mode of filter feeding. While *Daphnia* may be relatively common within specific sections of Lake Hopatcong, this genus was only identified at the mid-lake station during the 16 June 2006 sampling event. The generally low densities of herbivorous zooplankton in Lake Hopatcong observed in 2006 is similar to conditions measured during past monitoring years. The relatively low densities of herbivorous zooplankton may indicate that resident zooplankton-eating fishes (i.e. minnows, alewives, young yellow perch, white perch) were heavily grazing on large-bodied zooplankton in 2006.

Table 2
Zooplankton in Lake Hopatcong during the 2006 Growing Season

Sampling Date	Zooplankton
15 May 2006	The dominant zooplankton were the small-bodied cladoceran *Bosmina* and the rotifer *Asplanchna*. Some predatory copepods (*Cyclops* and *Mesocyclops*), the herbivorous copepod *Diaptomus* and juveniles (known as nauplii) were also found in the sample. In addition, other rotifers (*Keratella*, *Conochilus*) were also identified.
16 June 2006	Similar to 2004 and 2005, the small-bodied cladoceran *Bosmina* was by far the dominant zooplankter. Several rotifers (*Trichocera*, *Kellicottia*) and three herbivorous zooplankton (the cladocerans *Daphnia* and *Ceriodaphnia* and the copepod *Diaptomus*) were also identified in the sample.
25 July 2006	Overall zooplankton abundance was moderate, with the dominant genera being the rotifers *Conochilus* and *Asplanchna*. The herbivorous copepod *Diaptomus* was common. *Ceriodaphnia*, *Bosmina*, *Cyclops, Daphnia* and nauplii were also identified in the sample.
22 August 2006	Zooplankton abundance was low at this time with no one genus being the dominant zooplankter. The herbivorous cladoceran Ceriodaphnia was in the sample along with the cladocerans *Bosmina*, *Chydorus* and a variety of rotifers including *Conochilus*, *Asplanchna*, *Trichocera pilla* and *Keratella*
28 September 2006	The copepods *Cyclops* and *Mesocyclops* were the dominant zooplankton. Two herbivores, the cladoceran *Ceriodaphnia* and the copepod *Diaptomus*, were identified in the sample. Besides juvenile copepods (called nauplii), the rest of the identified zooplankton were rotifers (*Keratella*, *Trochosphaera, Polyarthra, Asplanchna*).

Recreational Fishery and Potential Brown Trout Habitat

Of the recreational game fish that reside or are stocked in Lake Hopatcong, trout are the most sensitive in terms of water quality. For their sustained management, all species of trout require DO concentrations of at least 4 mg/L or greater. However, the State's designated water quality criterion to sustain a healthy, aquatic ecosystem is a DO concentration of at least 5 mg/L.

While all trout are designated as coldwater fish, trout species display varying levels of thermal tolerance. Brown trout (*Salmo trutta*) have an optimal summer water temperature range of 18 to 24^{o}C (65 to 75^{o}F) (USEPA, 1994). However, these fish can survive in waters as warm as 26^{o}C (79^{o}F) (Scott and Crossman, 1973), defined here as acceptable habitat. The 2006 temperature and DO data for Lake Hopatcong were examined to identify the presence of optimal or acceptable brown trout habitat. As with previously monitoring reports, this analysis focused solely on *in-situ* data collected at the mid-lake sampling station (Station #2).

For the sake of this analysis, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures less than 24^{o}C were considered optimal habitat for brown trout. In contrast, sections of the lake that had DO concentrations equal to or greater than 5 mg/L and water temperatures between 24 and 26^{o}C were considered carry over habitat for brown trout.

In May 2006 optimal brown trout habitat was identified from the surface water down to a depth of 11 meters (36 feet) at Lake Hopatcong (Appendix B). By 16 June 2006, the optimal brown trout habitat was found from the surface to a depth of 8 meters (26 feet).

By 26 July 2006, carry over brown trout habitat was found between the surface and 5 meters (16.5 feet). However, by 22 August 2006, the carry over brown trout habitat zone slightly increased from the surface to a depth of 6 meters (19.8 feet). By late September optimal brown trout habitat returned and was distributed from the surface to a depth of 10 meters (33 feet). Based on these data varying levels of acceptable brown trout habitat persisted through the entire growing season in Lake Hopatcong.

Mechanical Weed Harvesting Program

Many of the more shallow sections of Lake Hopatcong are susceptible to the proliferation of nuisance densities of rooted aquatic plants. Given the size of Lake Hopatcong, the composition of its aquatic plant community, and its heavy and diverse recreational use, mechanical weed harvesting is the most cost effective and ecologically sound method of controlling nuisance weed densities. Thus, the weed harvesting program has been in operation at Lake Hopatcong since the mid-1980's with varying levels of success. However, one consistent advantage mechanical weed harvesting has over other management techniques, such as the application of herbicides, is that phosphorus is removed from the lake along with the weed biomass. In fact, based on a plant biomass study conducted at Lake Hopatcong in 2006, approximately 6% of the total phosphorus load targeted for reduction under the established TMDL is removed through the mechanical weed harvesting program.

During the last five growing seasons, since the State-designated Lake Hopatcong Commission has been operating the mechanical weed harvesting program, an average of 1,394 tons of aquatic vegetation is removed from the lake per year. Specifically in 2006, a total of 1,291 tons of aquatic vegetation was removed. This roughly equates to 2.6 million pounds of plant biomass removed from Lake Hopatcong in 2006, a 20 % increase from 2005. This increase was attributed to inter-annual variations in local climate, impacting the Lake Hopatcong ecosystem.

While the first half of the 2006-growing season was relatively wet and cool, the later half (July through August) was extremely dry and sunny, stimulating the growth of aquatic plants. The last portion of the growing season (September) was again wet with a moderate frequency of storm events carrying watershed-based nutrients to the lake. These stimulated high rates of aquatic plant growth, which resulted in the use of the mechanical weed harvesting program to removed nuisance plant densities. The increase in the amount of plant biomass removed from Lake Hopatcong in 2006, relative to 2005 and 2004, was largely attributed to prevailing weather conditions, particularly the dry and hot conducted of July and August.

As previously mentioned, Princeton Hydro conducted a biomass study of the aquatic vegetation of Lake Hopatcong in 2006. As part of the SFY 2006 Budget for the Lake Hopatcong Commission, some funds were allocated to conducting a study on quantifying the amount of phosphorus removed from Lake Hopatcong through the existing weed harvesting program. During two of the five monthly water quality monitoring events, 17 July 2006 and 28 September 2006, above sediment aquatic macrophytes (plants and filamentous algae) biomass were harvested and analyzed for total phosphorus. During each sampling event, a total of sixteen plant samples were collected throughout Lake Hopatcong. Every attempt was made to sample the same plant species in the same location during the September sampling event as was collected during the July sampling event, however harvesting and natural conditions prevented this in a few distinct locations.

During the 17 July sampling event, three samples of Eurasian watermilfoil, three samples of tapegrass and two samples of *Lyngbya* (a dark filamentous blue-green alga) were collected. In addition, one sample of each of the following aquatic plant species was collected: broad-leaf pondweed, elodea (common waterweed), yellow water lily and coontail. The remaining four samples were community-wide samples; meaning a collection of the natural assemblage of macrophytes within a specific site areas throughout the lake. The 28 September sample event of the aquatic macrophytes was similar to the July sampling event with a few differences. For example, only two tapegrass and three *Lyngbya* samples were collected in September. In addition, instead of collecting a sample of yellow water lily, two samples of broadleaf pondweed were collected in September.

It is interesting to note that there was the significant decline in plant-biomass TP concentrations from the July samples to the September samples. As can be seen in Table 3 below, in the sample locations where the same species of plant was collected during both sample collection events, the September plant-biomass TP concentrations were significantly less than the July TP concentrations.

As previously stated, it was determined using a combination of the data collected during the 2006 mechanical weed harvesting program and the results of the plant-biomass TP study, that approximately 6% of the TP load targeted for reduction under the lake's TMDL was removed through harvesting.

Table 3 – Lake Hopatcong 2006 Macrophyte Study TP concentrations

SPRING 2006			SUMMER 2006		
PLANT ID & LOCATION	TP (MG/KG)	% SOLIDS	PLANT ID & LOCATION	TP (MG/KG)	% SOLIDS
Milfoil - Crescent	2,360	6.7	Milfoil - Crescent	1,200	5.3
Milfoil - Raccoon Island	2,400	6.3	Milfoil - Raccoon Island	1,710	6.4
Milfoil - Jefferson	1,650	9.5	Milfoil - Jefferson	1,630	6.1
Vallisneria - Ingram	2,900	5.3	Vallisneria - Ingram	1,210	7
Vallisneria - Raccoon Island	1,850	5.6	N/A		
Vallisneria - Jefferson	1,340	6	Vallisneria - Jefferson	550	9.3
Lyngbya - ST-5	2,340	7.7	Lyngbya - ST-10	2,080	12
Lyngbya - ST-1	1,220	10.9	Lyngbya - ST-4	1,430	9.8
N/A			Lyngbya - Raccoon Island	2,400	14
N/A			Broad-leaf Pondweed Raccoon Island	1,440	10
Community - Raccoon Island	2,020	8.2	Community - Raccoon Island	1,740	11
Community - Outlet	3,140	6.3	Community - Outlet	1,390	8.6
Community - Ingram	3,930	6.2	Community - Ingram	3,240	6.4
Community - Jefferson	1,680	8.3	Community - Jefferson	1,140	7.3
Broad-leaf Pondweed - Jefferson	1,460	10.3	Broad-leaf Pondweed - Jefferson	1,200	7.6
Elodea - Jefferson	2,210	8.9	Elodea - Jefferson	1,950	7.8
Spatterdock - Raccoon Island	1,250	15	N/A		
Coontail - Raccoon Island	3,700	4.8	Coontail - Raccoon Island	1,310	5.5

Inter-annual Analysis of Water Quality Data

Annual mean values of Secchi depth, chlorophyll *a* and total phosphorus concentrations were calculated for the years 1991 through 2006. The annual mean values for Station #2 were graphed, along with the long-term, "running mean" for the lake.

The mean 2006 Secchi depth at Station #2 was 2.0 meters, which revealed the first increase in Secchi depth recorded at Lake Hopatcong since 2002 (Figure 3). While the mean Secchi depth was above the 1.0-meter threshold for recreational waterbodies, it was the still one of the lowest means measured at Lake Hopatcong. The lowest mean Secchi depth at Lake Hopatcong was 1.6 meters, measured in both 1994 and 1997. Similar to 2005, the first half of the 2006 growing season experienced a high frequency of storm events, followed by extremely dry and hot conditions during the later half of the season. Thus, the lack of storms in the second half of the 2006 growing season allowed nutrients that entered the lake via the spring and early summer storms to remain "in place" and not be flushed from the system. In turn, the elevated phosphorus load and lowered flushing rate stimulate algal growth.

Based on Princeton Hydro's in-house database, Secchi depths greater than 1 m (3.3 ft) are considered acceptable for recreational waterbodies; Secchi depths less than 1 m are perceived as "dirty" or "cloudy" to the layperson. Thus, while the 2006 mean Secchi depth was lower than what has been measured in previous years (i.e. 2001-2002), Lake Hopatcong's water clarity again remained acceptable in terms of recreational use.

One of the major factors responsible for the observed water clarity of a lake is the amount of algal biomass in the water. In other words, the less algae in the water, the higher the water clarity. An effective way of quantifying algae biomass is to measure the amount of chlorophyll *a* in the water. Chlorophyll *a* is a photosynthetic pigment all algae possess, so measuring chlorophyll *a* provides a measurement of the amount of algae biomass in the open waters of a lake.

The relatively low mean Secchi depth in 2006 correlated well with the relatively higher mean chlorophyll *a* concentration. The 2006 annual mean chlorophyll *a* concentration for Station #2 was 10.4 mg/m^3 (Figure 4). While the 2006 chlorophyll *a* mean was slightly lower than the 2005 mean, it is still an elevated concentration since the long-term monitoring program was initiated in the early 1990's (Figures 4). Elevated amounts of algal biomass in Lake Hopatcong can be attributed to in increase in phosphorus loading, coupled with a reduced flushing rate late in the growing season. Such conditions emphasize the need for watershed-based control measured to reduce the existing phosphorus loads entering Lake Hopatcong.

While the 2006 mean chlorophyll *a* concentration was relatively elevated, it was still below the

30 mg/m^3 threshold, when laypeople perceive water quality problems (i.e. algal blooms) in terms of recreational use. Neither the 2006 chlorophyll *a* mean, nor any of the actual concentrations measured at the mid-lake, deep water station (Station #2) were equal to or greater than 30 mg/m^3. However, some single chlorophyll *a* measurements, specifically at Station #3 during the mid-summer months, did exceed the 30 mg/m^3 threshold.

For most waterbodies in the northeastern portion of the United States, phosphorus is the primary nutrient limiting algal growth. This means that higher amounts of phosphorus entering a lake or pond, typically translates into more algae being produced. Past studies have demonstrated that phosphorus is the primary limiting nutrient for algae in Lake Hopatcong.

The 2006 annual mean TP concentration was again 0.02 mg/L, consistent with the 2005 mean of 0.02 mg/L (Figure 5). While the 2006 TP mean was again the second highest measured in Lake Hopatcong over the last six years (Figure 5), it is relatively low. The low mean TP concentration in 2006, relative to the elevated chlorophyll *a* concentration and low Secchi depth mean values, indicates that the algae at Station #2 may have originated from sections of the lake and were transported to the mid-lake area through wind and wave action. Similar observations were made in 2004 and 2005 and based on its proximity, it is more than likely that the River Styx / Crescent Cove section of the lake is the origin of a least a portion of the algae found in the mid-lake section.

Baseline Tributary Monitoring Program

As previously described, four baseline tributary sampling events occurred at Lake Hopatcong from September to November 2006. These samples were analyzed for TP, TDP, SRP, NO_3-N and TSS. The location of the sampling stations is provided in Appendix A, while the raw data are provided in Appendix C.

Concentrations of all three phosphorus species analyzed were low at all three baseline tributary stations during all four sampling events; SRP concentrations were less than 0.009 mg/L, TDP concentrations were less 0.01 mg/L with one measurement at 0.02 mg/L, and TP concentrations were equal to or less than 0.02 mg/L with one measurement at 0.03 mg/L (Appendix C). Baseline tributary TSS concentrations were less than or equal to 3 mg/L, well below the 25 mg/L threshold where the water appears muddy to the layperson.

Baseline tributary NO_3-N concentrations were generally low, varying between < 0.02 to 3.3 mg/L. All measured NO_3-N concentrations were well below the State and Federal standard for drinking water of 10 mg/L. However, during three of the four sampling events, the Quarry Brook had a NO_3-N greater than 1 mg/L. Such concentrations are high enough to stimulate high rates of in-stream algal growth.

Based on the collected baseline tributary water quality data, the stream sections immediately upstream of the sampling locations more than likely not exhibit severe streambank erosion. Streambanks with severe erosion tend to have elevated TP and/or TSS concentrations, even during baseline conditions. In addition, the moderately elevated NO_3-N concentrations within the Quarry Brook may indicate septic leachate or some other sub-surface source of NO_3-N directly entering the brook.

Stormwater Monitoring Program

A total of four pre-installation stormwater monitoring events were conducted from September to December 2006 as part of the Commission's existing 319 grant. During two of these four stormwater monitoring events, there was an insufficient amount of storm flow to collect stormwater at sampling station 3, the roadside swale along Dupont Avenue (Appendix A). The composited stormwater samples were analyzed for SRP, TDP, TP and TSS.

The degree of variability of the stormwater water quality results was considerable larger than those measured during the 2006 baseline tributary monitoring program (Appendix C). For the 2006 pre-installation stormwater data, SRP concentrations varied between 0.011 and 0.079 mg/L, TDP concentrations varied between 0.01 and 0.10 mg/L, TP concentrations varied between 0.04 and 0.15 mg/L, and TSS concentrations varied between < 2 and 39 mg/L. These results indicate, as was expected, that the majority of the watershed-based phosphorus and TSS pollutant loads entering Lake Hopatcong originate from stormwater.

Based on other watershed studies, the majority (> 80%) of phosphorus in stormwater tends to be adsorbed onto sediment particles. However, based on the results of the Lake Hopatcong stormwater monitoring program, particulate phosphorus (i.e. adsorbed onto sediment particles) accounted for between 0 to 50% of the total phosphorus in the stormwater. The one exception to this was the Jefferson stormwater sampling station, where 86% of the total phosphorus was in a particulate form during the 13 December 2006 sampling event.

The pre-installation stormwater results indicate that conventional basins that rely on removing the bulk of stormwater phosphorus through settling will not been highly efficient. Given the fact that for the most part, the majority of the stormwater phosphorus entering Lake Hopatcong is in a dissolved form, structural Best Management Practices (BMPs) that include mechanisms to remove this fraction of phosphorus should be installed. Indeed, this is why the three larger BMPs that will be installed as part of the 319 grant are Aqua-Filters, which include filter media that remove dissolved forms of phosphorus from the incoming stormwater.

4.0 SUMMARY

This report documents the findings of the 2006 Lake Hopatcong water quality monitoring program. This section provides a summary of the 2006 water quality conditions, as well as recommendations on how to preserve the highly valued aquatic resources of Lake Hopatcong.

1. Based on the 2006 water quality database, and similar to past monitoring years, the water quality conditions of Lake Hopatcong were generally consistent with those of a meso- to slightly eutrophic ecosystem.

2. Lake Hopatcong was thermally stratified from mid-June through late-September 2006. The strength of this thermal stratification was strongest during July and August.

3. Overall, the surface waters (to approximately 5 meters) of Lake Hopatcong remained well oxygenated (dissolved oxygen concentrations > 4 mg/L) throughout the monitoring season. An anoxic zone (waters with DO concentrations less than 1 mg/L) developed along the lake's bottom by mid-June. This is in contrast to some of the previous monitoring years, when anoxic is typically first detected in May. By late July, this layer of anoxic water had reached a depth of 6 meters from the surface.

4. It has been well documented that phosphorus is the primary limiting nutrient in Lake Hopatcong. That is, a slight increase in phosphorus will result in a substantial increase amount of algal and/or aquatic plant biomass. TP concentrations in the surface waters of Lake Hopatcong typically varied between <0.01 mg/L and 0.08 mg/L, consisting of concentrations both above and below the 0.06 mg/L bloom threshold.

5. While the chlorophyll *a* concentrations were not excessive at the mid-lake sampling station, other sections of the lake experienced nuisance algal blooms. As is typical each year, Station #3 (Crescent Cove / River Styx) experienced nuisance algal blooms through the summer months.

6. Based on the *in-situ* conditions, hold over brown trout habitat was available throughout the entire 2006 growing season. Such results are consistent with those measured in previous monitoring years at Lake Hopatcong.

7. The annual average Secchi depth at the mid-lake sampling station was 2.0 meters. While this Secchi depth is an increase from the 2005 value and acceptable for a recreational waterbody, it is still one of the lowest averages in Lake Hopatcong since 1997.

8. Similar to Secchi depth, the average chlorophyll *a* concentration for 2006 was acceptable for a recreational waterbody, however, relative to past monitoring years, it was one of the higher values measured in Lake Hopatcong. This elevated average chlorophyll *a* concentration was attributed to an elevated phosphorus load as a result of the high frequency of storm events early in the growing season, followed by relatively dry and hot conditions experienced during the later half of the growing season.

9. Over the last five growing seasons, an average of approximately 1,394 tons of aquatic plant biomass was harvested from Lake Hopatcong per year. Approximately 1,291 tons of aquatic plant biomass was removed in 2006, an approximately 20% increase from 2005 removals. The mechanical weed-harvesting program increases the recreational and ecological value of Lake Hopatcong, as well as removes a phosphorus source from the lake. Thus, this in-lake management technique should continue to be used at Lake Hopatcong.

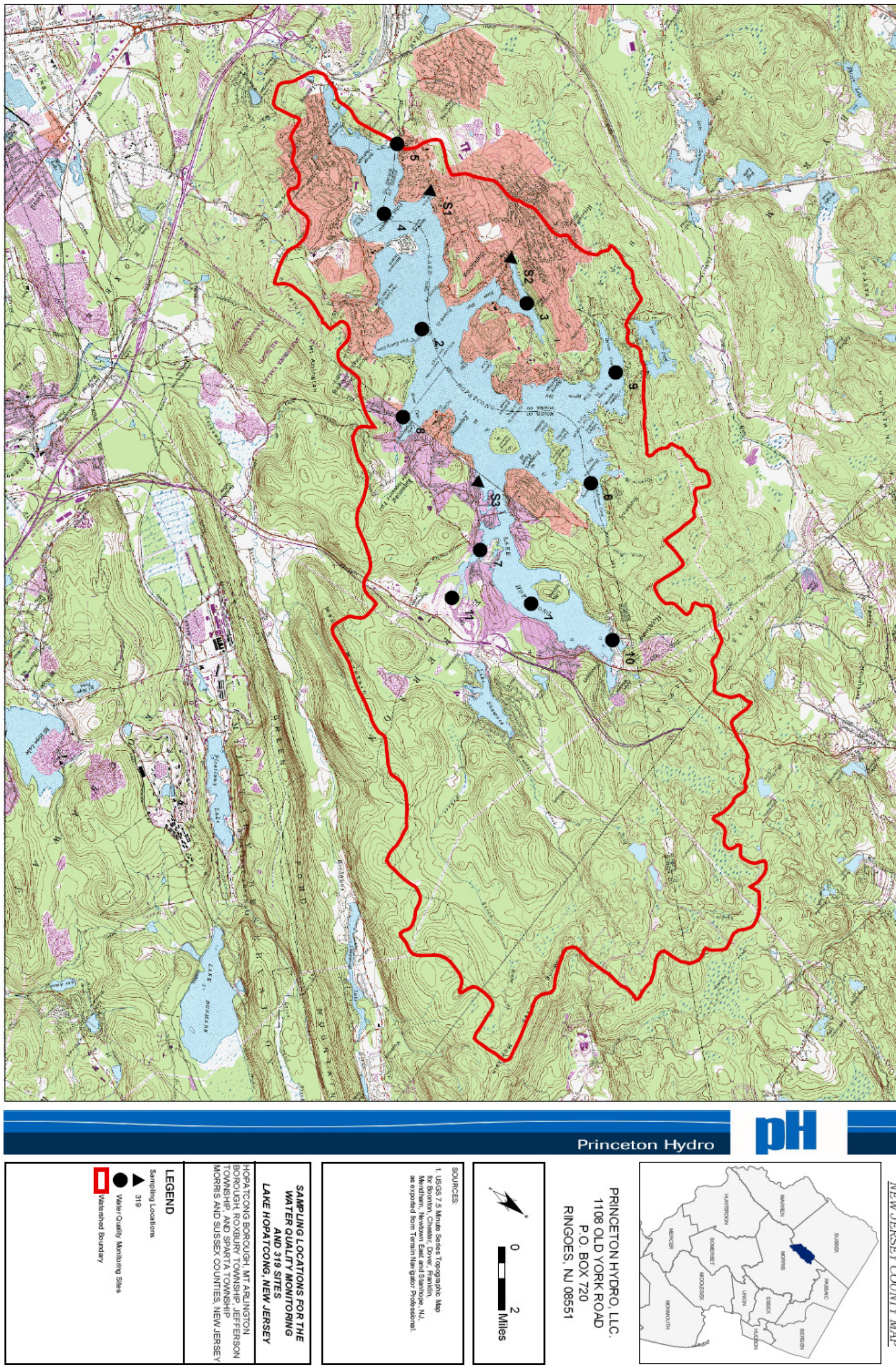
10. The 2006 aquatic plant-biomass TP study revealed that the plants appear to have more phosphorus per unit weight early in the growing season relative to later. In addition, approximately 6% of the TP load targeted for removal under the TMDL was removed through the mechanical weed harvesting program.

11. Baseline tributary concentrations of the various phosphorus species and TSS were low in Lake Hopatcong. Nitrate-N concentrations were relatively low with the exception of moderate baseline tributary concentrations at Quarry Brook. The results of the tributary monitoring program indicates that baseline flow accounts for a minor portion of the phosphorus and TSS loads entering Lake Hopatcong.

12. Pre-installation stormwater phosphorus (SRP, TDP and TP) and TSS concentrations collected as part of the 319 grant were variable. In addition, a substantial fraction of the measured phosphorus was in a dissolved form. These results indicate that BMPs that include mechanisms to reduce dissolved, as well as particulate, forms of phosphorus are required to reduce the total phosphorus loads entering Lake Hopatcong.

APPENDIX A

FIGURES


Princeton Hydro
NEW JERSEY COUNTY MAP
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
0
2
Miles
SOURCES:
1. USGS 7.5 Minute Series Topographic Map for Boonton, Chester, Dover, Franklin, Mendham, Newtown East and Stanhope, NJ, as exported from Terrain Navigator Professional.
SAMPLING LOCATIONS FOR THE WATER QUALITY MONITORING AND 319 SITES
LAKE HOPATCONG, NEW JERSEY
HOPATCONG BOROUGH, MT ARLINGTON BOROUGH, ROXBURY TOWNSHIP, JEFFERSON TOWNSHIP, AND SPARTA TOWNSHIP
MORRIS AND SUSSEX COUNTIES, NEW JERSEY
LEGEND
Sampling Locations
319
Water Quality Monitoring Sites
Watershed Boundary

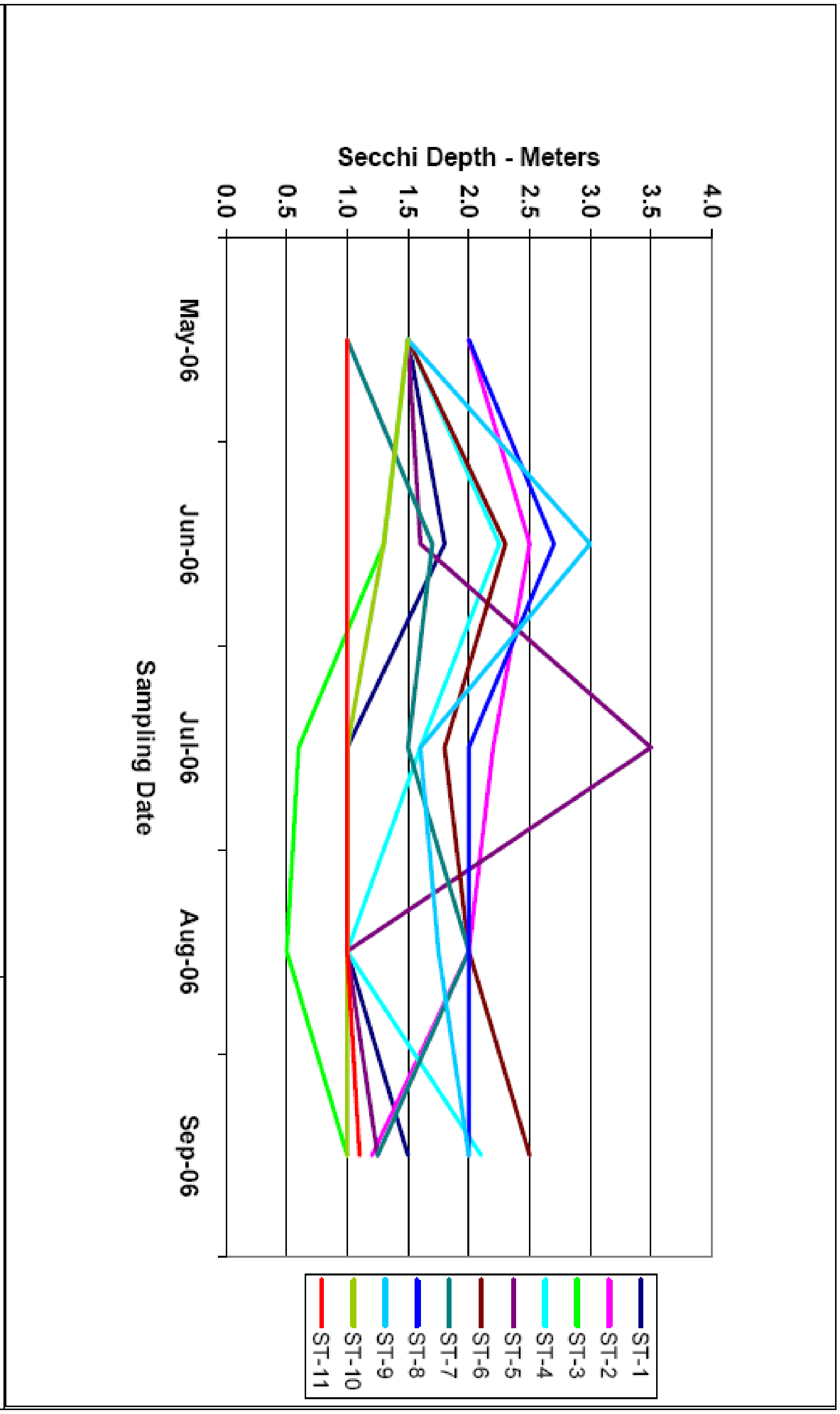


Figure 2 - Lake Hopatcong 2006 Secchi depth values

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

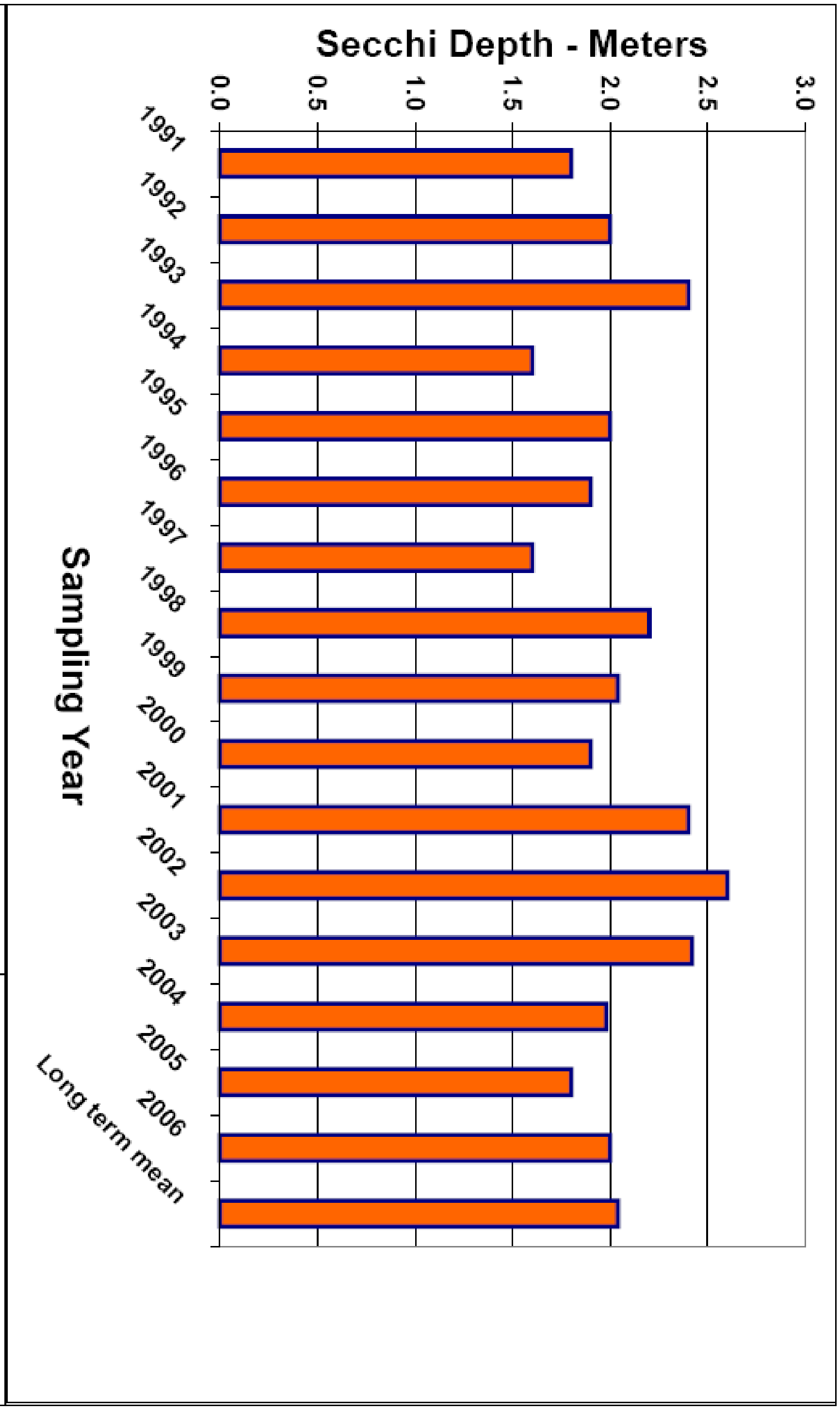


Figure 3 - Lake Hopatcong Long Term
Secchi Depth Values at Station #2

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

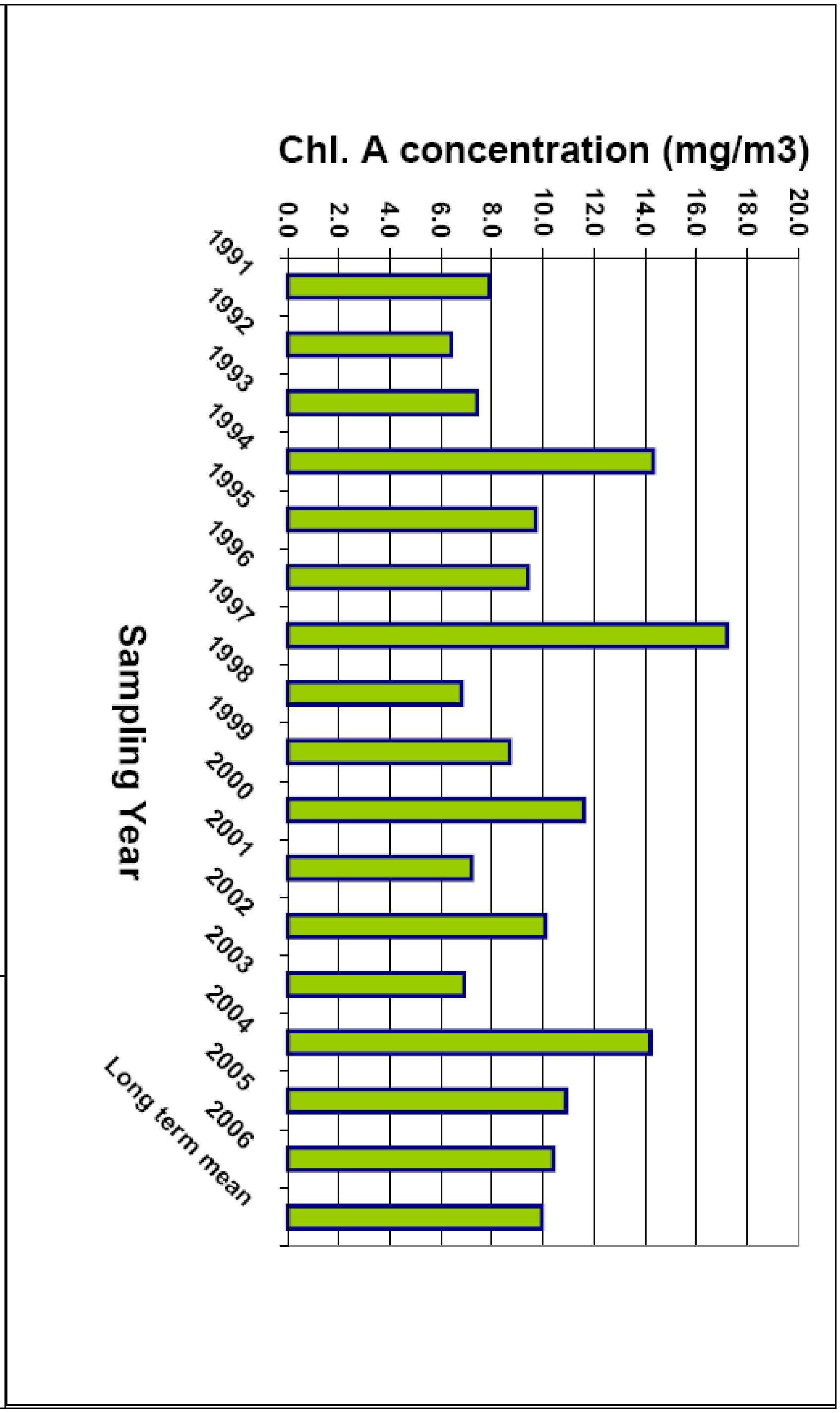


Figure 4 - Lake Hopatcong Long Term Chl A concentrations at Station #2

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551

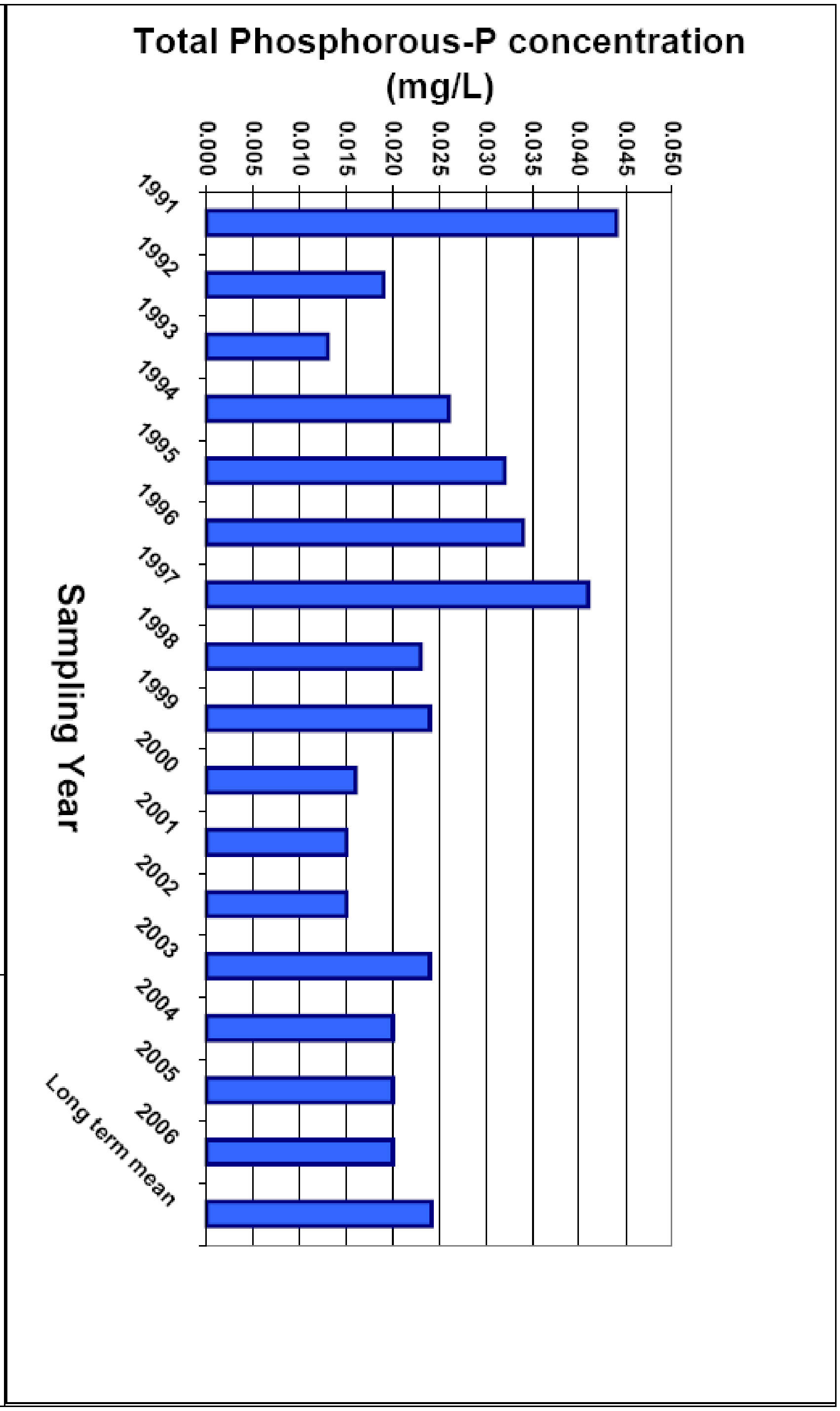
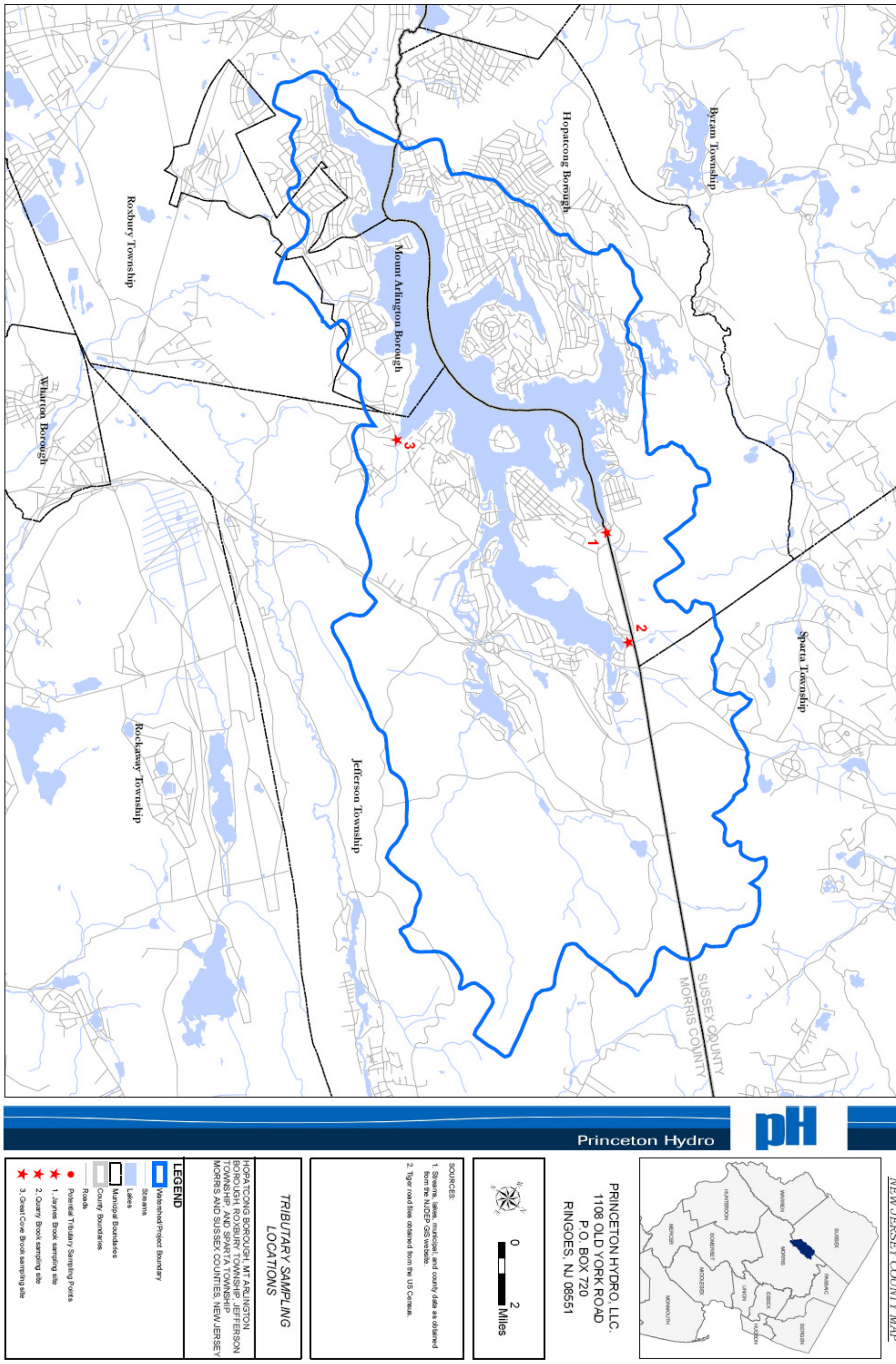
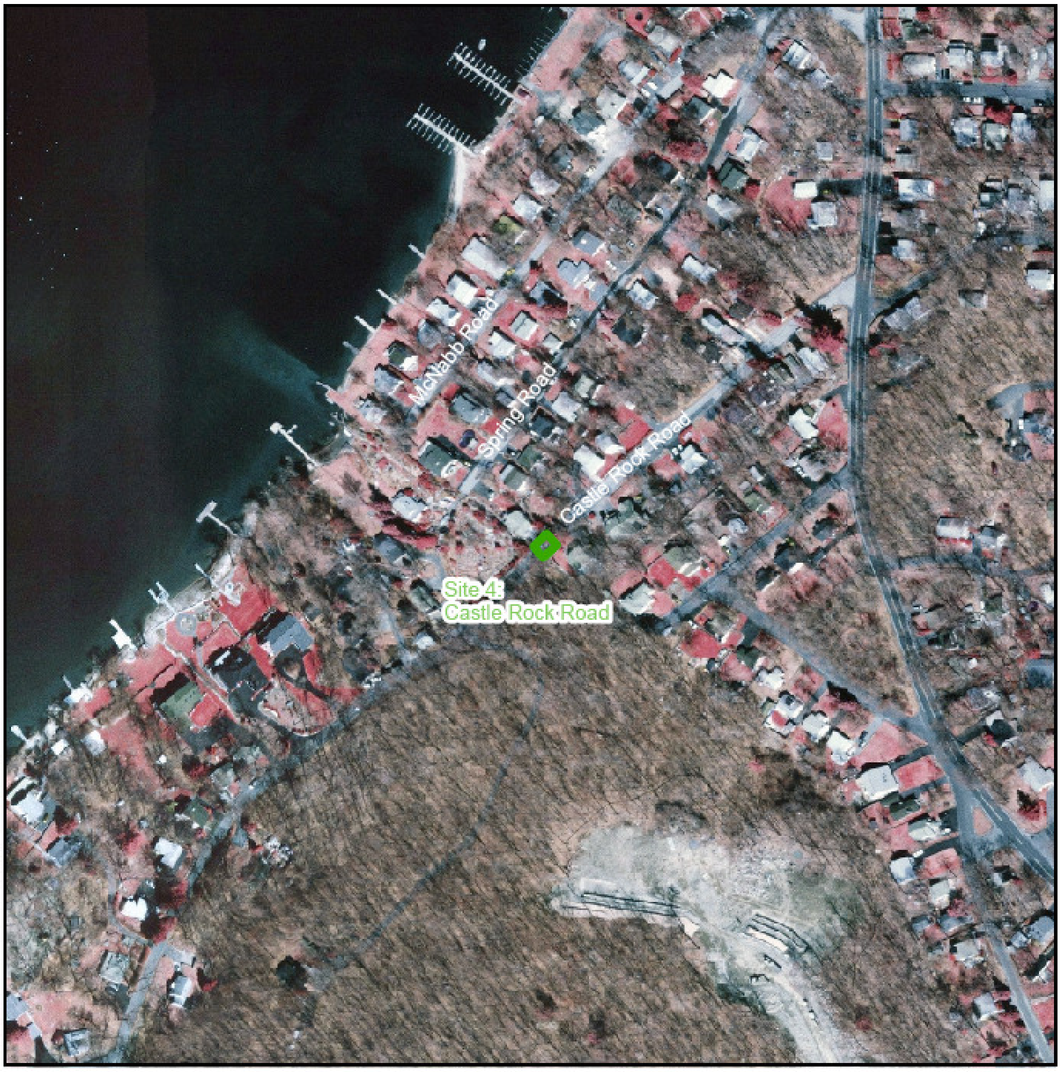


Figure 5 - Lake Hopatcong Long Term TP concentrations at Station #2

Princeton Hydro, L.L.C.
1108 Old York Road
Ringoes, N. J. 08551


Byram Township
Hopatcong Borough
Roxbury Township
Mount Arlington Borough
Wharton Borough
Rockaway Township
Jefferson Township
Sparta Township
SUSSEX COUNTY
MORRIS COUNTY
1
2
3
Princeton Hydro
NEW JERSEY COUNTY MAP
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
0
2
Miles
SOURCES:
1. Streams, lakes, municipal, and county data as obtained from the NJDEP GIS website.
2. Tiger road files obtained from the US Census.
TRIBUTARY SAMPLING LOCATIONS
HOPATCONG BOROUGH, MT ARLINGTON BOROUGH, ROXBURY TOWNSHIP, JEFFERSON TOWNSHIP, AND SPARTA TOWNSHIP
MORRIS AND SUSSEX COUNTIES, NEW JERSEY
LEGEND
Watershed/Project Boundary
Streams
Lakes
Municipal Boundaries
County Boundaries
Roads
Potential Tributary Sampling Points
1. Jaynes Brook sampling site
2. Quarry Brook sampling site
3. Great Cove Brook sampling site


Dupont Avenue
Crescent Road
Bell Avenue
Site 1:
Crescent Cove
Site 2:
Bell Avenue
Site 3:
Dupont Avenue
Princeton Hydro
pH
SITE 1: CRESCENT COVE AQUAFILTER
SITE 2: BELL AVENUE AQUAFILTER
SITE 3: DUPONT BIORETENTION SWALE
BOROUGH OF HOPATCONG
SUSSEX COUNTY, NEW JERSEY
Legend
Project Site
0
240
feet
1 inch equals 240 feet
PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551
SOURCES:
1. New Jersey 2002 High Resolution Orthophotography obtained from the New Jersey Image Warehouse.
NEW JERSEY COUNTY MAP
SUSSEX
PASSAIC
BERGEN
WARREN
MORRIS
ESSEX
HUDSON
UNION
HUNTERDON
SOMERSET
MIDDLESEX
MERCER
MONMOUTH



Princeton Hydro

SITE 4: CASTLE ROCK ROAD

TOWNSHIP OF JEFFERSON
MORRIS COUNTY, NEW JERSEY

Legend

Project Site

0 240 feet

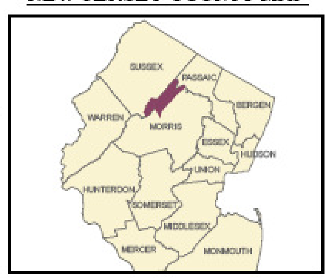
1 inch equals 240 feet

PRINCETON HYDRO, LLC.
1108 OLD YORK ROAD
P.O. BOX 720
RINGOES, NJ 08551

SOURCES:

1. New Jersey 2002 High Resolution Orthophotography obtained from the New Jersey Image Warehouse.

NEW JERSEY COUNTY MAP



APPENDIX B

IN-SITU DATA

In-Situ Monitoring for Lake Hopatcong 5/15/06							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.5	1.5	Surface	16.5	0.355	8.87	8.11
			1.0	16.51	0.362	8.98	8.16
ST-2	12.5	2	Surface	15.9	0.376	9.51	8.16
			1.0	15.92	0.376	9.49	8.12
			2.0	15.92	0.376	9.43	8.09
			3.0	15.91	0.376	9.48	8.08
			4.0	15.91	0.376	9.47	8.07
			5.0	15.91	0.376	9.45	8.06
			6.0	15.88	0.376	9.46	8.04
			7.0	15.38	0.375	9.13	7.85
			8.0	13.45	0.377	7.54	7.76
			9.0	12.27	0.375	6.99	7.66
			10.0	11.61	0.375	6.45	7.59
			11.0	11.25	0.376	5.75	7.51
			12.0	10.77	0.377	4.76	7.39
			12.5	10.36	0.384	3.42	7.29
ST-3	2	1.5	Surface	16.99	0.443	9.5	10.87
			1.0	17	0.442	9.79	10.64
			2.0	16.99	0.441	9.39	9.51
ST-4	3	1.5	Surface	16.24	0.383	9.12	8.15
			1.0	16.24	0.382	9.03	8.16
			2.0	16.24	0.382	8.97	8.18
			3.0	16.25	0.382	8.13	8.12
ST-5	2.8	1.5	Surface	16.37	0.391	8.56	9.03
			1.0	16.37	0.39	8.6	9.12
			2.0	16.27	0.39	8.65	9.19
			2.8	16.26	0.39	8.53	9.19
ST-6	2.9	1.5	Surface	15.17	0.375	8.82	7.93
			1.0	15.17	0.375	8.74	7.88
			2.0	15.12	0.375	8.64	7.83
			2.9	15.03	0.375	8.26	7.75
ST-7	1	1	Surface	16.04	0.158	8.05	7.69
			1.0	16.03	0.159	7.68	7.54
ST-8	7	2	Surface	15.15	0.375	9.07	7.91
			1.0	15.17	0.375	8.97	7.83
			2.0	15.15	0.375	8.97	7.79
			3.0	15.15	0.376	8.96	7.78
			4.0	14.77	0.376	8.82	7.76
			5.0	14.49	0.376	8.49	7.71
			6.0	14.39	0.376	8.24	7.67
			7.0	13.94	0.376	7.74	7.61
ST-9	8	1.5	Surface	16.64	0.375	9.57	8.15
			1.0	16.65	0.375	9.56	8.15
			2.0	16.76	0.376	9.52	8.15
			3.0	16.78	0.377	9.5	8.15
			4.0	16.81	0.378	9.51	8.15
			5.0	16.78	0.377	9.52	8.15
			6.0	16.71	0.376	9.53	8.15
			7.0	14.78	0.376	9.15	8.08
			8.0	13.34	0.376	5.78	7.77
ST-10	1.5	1.5	Surface	16.7	0.38	8.93	8.02
			1.0	16.59	0.38	8.8	8.04
ST-11	1.2	1	Surface	15.95	0.148	7.82	7.74
			1.0	15.97	0.155	7.68	7.59

In-Situ Monitoring for Lake Hopatcong 6/16/06							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.8	1.8	Surface	21.39	0.343	8.92	7.74
			1.0	21.12	0.35	9.04	7.7
			1.5	20.92	0.355	8.9	7.73
ST-2	14.5	2.5	Surface	19.72	0.383	9.51	8.09
			1.0	19.72	0.382	9.44	8
			2.0	19.66	0.383	9.4	7.98
			3.0	19.65	0.383	9.42	8
			4.0	19.52	0.383	9.36	7.96
			5.0	19.37	0.383	9.2	7.9
			6.0	17.75	0.383	7.7	7.49
			7.0	16.43	0.386	6.41	7.31
			8.0	15.69	0.388	5.12	7.14
			9.0	15.37	0.388	4.5	7.07
			10.0	14.62	0.389	3.34	6.97
			11.0	13.89	0.389	2.17	6.9
			12.0	13.47	0.39	1.21	6.85
			13.0	13.26	0.391	0.7	6.8
			14.0	12	0.408	0.4	6.75
ST-3	2	1.3	Surface	21.61	0.572	9.63	8.55
			1.0	20.71	0.563	9.8	8.63
			2.0	19.76	0.467	7.6	7.85
ST-4	2.5	2.25	Surface	20.5	0.387	10.11	9.07
			1.0	20.5	0.387	9.83	9.07
			2.0	20.47	0.387	10.02	9.13
ST-5	3.2	1.6	Surface	20.12	0.395	9.58	8.69
			1.0	20.48	0.395	9.11	8.87
			2.0	20.16	0.396	8.95	8.8
			3.0	20.02	0.399	5.51	7.68
ST-6	2.3	2.3	Surface	20.54	0.38	9.42	8.12
			1.0	19.57	0.38	9.4	8.13
			2.0	19.02	0.382	10.62	8.75
ST-7	1.7	1.7	Surface	21.48	0.226	8.29	7.37
			1.0	20.71	0.22	7.9	7.29
ST-8	7.4	2.7	Surface	19.34	0.381	9.24	7.46
			1.0	19.34	0.382	8.97	7.7
			2.0	19.3	0.382	9.17	7.86
			3.0	19.28	0.382	9.07	7.92
			4.0	19.28	0.382	9.21	7.94
			5.0	19.26	0.382	9	7.94
			6.0	19.26	0.382	9.03	7.93
			7.0	16.62	0.386	5.63	7.5
ST-9	8	3	Surface	20.05	0.382	9.2	7.91
			1.0	19.53	0.383	9.24	7.9
			2.0	18.88	0.386	9.08	7.92
			3.0	18.76	0.386	8.93	7.9
			4.0	18.59	0.386	8.85	7.85
			5.0	18.28	0.387	8.45	7.73
			6.0	17.94	0.385	8.58	7.67
			7.0	17.06	0.385	7.76	7.49
			8.0	16.02	0.39	4.52	7.3
ST-10	1.3	1.3	Surface	20.81	0.38	9.18	8.04
			1.0	20.5	0.382	9.08	8.1
ST-11	1	1	Surface	21.71	0.165	7.93	7.58
			1.0	20.12	0.164	7.94	7.32

***In-Situ* Monitoring for Lake Hopatcong 7/26/06**

Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(°C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.8	1	0.5	26.65	0.355	7.3	7.4
			1.0	26.44	0.355	7.09	7.36
			1.5	26.39	0.354	6.93	7.42
ST-2	49 ft	2.2	0.5	25.94	0.375	7.67	7.62
			1.0	25.93	0.374	7.65	7.67
			2.0	25.93	0.374	7.83	7.65
			3.0	25.93	0.374	7.95	7.44
			4.0	25.9	0.374	7.72	7.28
			5.0	25.59	0.375	6.12	6.92
			5.5	23.72	0.375	0.7	6.84
			6.0	22.44	0.378	0.4	6.65
			7.0	19.39	0.385	0.42	6.65
			8.0	16.73	0.388	0.45	6.68
			9.0	15.19	0.389	0.46	6.71
			10.0	14.49	0.39	0.48	6.67
			11.0	14	0.394	0.5	6.66
			12.0	13.84	0.391	0.53	6.87
			13.0	13.5	0.398	0.56	6.63
			14.0	12.34	0.415	0.7	6.91
ST-3	2	2 ft	0.5	27.65	0.58	9.91	8.81
			1.0	27.12	0.587	9.38	8.68
			2.0	26.03	0.594	1	7.28
ST-4	3	1.6	0.5	26.48	0.384	7.85	7.65
			1.0	26.43	0.384	7.49	7.62
			2.0	26.33	0.384	7.27	7.54
			2.5	26	0.381	6.41	7.48
ST-5	3.5	3.5	0.5	26.78	0.388	7.65	7.86
			1.0	26.66	0.389	7.62	7.61
			2.0	26.08	0.389	6.73	7.39
			3.0	25.49	0.394	0.86	7.09
ST-6	3	1.8	0.5	26.94	0.37	8.35	7.96
			1.0	26.94	0.37	8.39	7.91
			2.0	26.69	0.369	8.48	7.72
			2.5	26.38	0.369	6.57	7.35
ST-7	1.5	1.5	0.5	25.85	0.249	6.41	7
			1.0	25.44	0.251	6.56	7.01
			1.5	25.22	0.255	7.23	7.05
ST-8	24 ft	2	0.5	26.45	0.374	7.66	7.76
			1.0	26.45	0.374	8.05	7.75
			2.0	26.44	0.374	7.7	7.73
			3.0	26.41	0.374	7.64	7.68
			4.0	26.4	0.374	7.51	7.59
			5.0	26.37	0.375	7.47	7.35
			6.0	25.3	0.376	4.43	6.84
			7.0	20.87	0.38	0.34	6.7
ST-9	7.5	1.6	surface	26.55	0.372	8.08	7.96
			0.5	26.5	0.371	7.95	7.91
			1.0	26.45	0.371	7.81	7.77
			2.0	26.3	0.371	7.45	7.55
			3.0	25.85	0.371	6.83	7.16
			4.0	25.68	0.373	5.16	6.83
			5.0	22.45	0.375	0.19	6.59
			6.0	21.08	0.379	0.15	6.66
			7.0	20.14	0.384	0.21	6.75
			7.5	11.15	0.39	0.37	6.85
ST-10	1.6	1	0.5	26.85	0.359	9.04	8.27
			1.0	26.81	0.358	8.78	8.31
			1.5	26.38	0.361	10.8	8.89
ST-11	1.1	1	0.5	24.67	0.22	6.79	6.88
			1.0	24.55	0.219	6.59	6.89

In-Situ Monitoring for Lake Hopatcong 8/22/06							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	1.75	1	Surface	25.38	0.352	7.46	7.79
			1.0	25.18	0.352	7.17	7.62
			1.5	24.44	0.352	7.13	7.58
ST-2	13.5	2	Surface	24.66	0.372	7.76	7.82
			1.0	24.48	0.372	7.42	7.78
			2.0	24.34	0.371	7.53	7.75
			3.0	24.3	0.37	7.47	7.68
			4.0	24.28	0.372	7.52	7.64
			5.0	24.25	0.371	7.46	7.62
			6.0	24.18	0.37	7.43	7.59
			7.0	23.12	0.371	5.47	7.29
			8.0	18.74	0.379	1.52	6.98
			9.0	16.65	0.382	<1.0	6.78
			10.0	15.32	0.384	<1.0	6.71
			11.0	14.28	0.387	<1.0	6.81
			12.0	12.54	0.41	<1.0	6.85
			13.0	12.04	0.415	<1.0	6.75
ST-3	2	0.5	Surface	25.97	0.442	8.69	8.7
			1.0	24.74	0.44	8.44	8.62
			2.0	24.06	0.437	6.67	8.02
ST-4	2.5	1	Surface	24.82	0.385	8.12	7.9
			1.0	24.5	0.382	7.8	7.91
			2.0	24.34	0.384	7.89	7.9
ST-5	1.75	1	Surface	24.84	0.387	7.5	7.91
			1.0	24.43	0.386	7.8	8.01
ST-6	2.5	2	Surface	25.33	0.373	8.01	8.06
			1.0	25.26	0.374	7.98	8.04
			2.0	24.77	0.373	8.5	8.62
ST-7	2	2	Surface	25.27	0.337	7.32	7.58
			1.0	24.43	0.337	6.92	7.5
			2.0	24.04	0.342	7.38	7.47
ST-8	7.25	2	Surface	24.83	0.373	7.42	7.8
			1.0	24.55	0.372	7.41	7.78
			2.0	24.33	0.372	7.47	7.75
			3.0	24.2	0.372	7.35	7.69
			4.0	24.16	0.372	7.26	7.62
			5.0	24.13	0.371	7.21	7.54
			6.0	24.1	0.371	7.27	7.46
			7.0	24.07	0.371	6.83	7.42
ST-9	8.2	1.75	Surface	25.44	0.374	7.56	7.88
			1.0	25.36	0.373	7.46	7.83
			2.0	24.32	0.372	7.67	7.83
			3.0	24.21	0.373	7.64	7.81
			4.0	24.12	0.371	6.58	7.63
			5.0	24.08	0.372	7.07	7.47
			6.0	23.82	0.372	6.06	7.2
			7.0	22.23	0.371	1.76	7.18
			8.0	18.65	0.389	<1.0	6.76
ST-10	1.3	1	Surface	25.01	0.358	7.68	7.91
			1.0	24.46	0.357	7.67	7.83
ST-11	1	1	Surface	24.43	0.326	6.73	7.58
			1.0	23.36	0.323	6.57	7.49

In-Situ Monitoring for Lake Hopatcong 9/28/06							
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)
ST-1	2	1.5	Surface	18.76	0.355	10.21	7.86
			1.0	18.77	0.355	9.78	7.84
			2.0	18.58	0.355	9.81	7.8
ST-2	14.5	1.2	Surface	18.86	0.373	10.06	7.65
			1.0	18.82	0.374	9.53	7.57
			2.0	18.83	0.373	9.35	7.57
			3.0	18.77	0.373	9.17	7.54
			4.0	18.69	0.374	9.09	7.52
			5.0	18.68	0.374	9.08	7.49
			6.0	18.64	0.374	8.91	7.46
			7.0	18.61	0.373	8.9	7.48
			8.0	18.59	0.374	8.8	7.39
			9.0	18.45	0.374	7.93	7.73
			10.0	18.26	0.374	6.5	7.25
			11.0	16.16	0.388	<1.0	7.01
			12.0	14	0.413	<1.0	6.89
			13.0	12.78	0.428	<1.0	6.91
			14.0	12.36	0.444	<1.0	7.21
ST-3	2	1	Surface	19.26	0.418	9.79	7.7
			1.0	19.26	0.425	9.54	7.61
			2.0	19.05	0.425	9.12	7.63
ST-4	2.9	2.1	Surface	18.52	0.379	11.36	8.27
			1.0	18.49	0.379	10.61	8.31
			2.0	18.41	0.378	10.62	8.36
			2.5	18.42	0.379	10.49	8.44
ST-5	1.25	1.25	Surface	18.65	0.376	10.66	8.47
			1.0	18.5	0.375	10.61	8.54
ST-6	2.5	2.5	Surface	19.59	0.37	10.67	8.34
			1.0	19.58	0.37	10.6	8.45
			2.0	18.46	0.369	11.7	8.96
ST-7	1.75	1.25	Surface	18.25	0.237	9.38	7.65
			1.0	17.66	0.239	9.63	7.43
			1.5	17.38	0.24	9.3	7.38
ST-8	7.5	2	Surface	19.02	0.374	9.96	7.8
			1.0	18.96	0.373	9.8	7.75
			2.0	18.83	0.373	9.66	7.73
			3.0	18.82	0.374	9.45	7.7
			4.0	18.19	0.374	9.27	7.66
			5.0	18.18	0.374	9.35	7.62
			6.0	18.64	0.374	8.6	7.53
			7.0	18.61	0.376	8.38	7.45
ST-9	8	2	Surface	19.52	0.374	10.24	7.84
			1.0	19.44	0.372	9.92	7.82
			2.0	19.01	0.372	9.92	7.82
			3.0	18.92	0.372	9.69	7.79
			4.0	18.87	0.372	9.37	7.71
			5.0	18.8	0.372	9.15	7.53
			6.0	18.76	0.373	9.17	7.57
			7.0	18.76	0.373	9.21	7.53
			8.0	18.55	0.375	<1.0	7.4
ST-10	1.5	1	Surface	19.04	0.366	12.37	8.73
			1.0	19.01	0.368	12.25	8.66
ST-11	1.1	1.1	Surface	17.77	0.204	9.02	7.64
			1.0	17.24	0.196	9.24	7.5

APPENDIX C

WATER QUALITY DATA

HOPATCONG
15-May-2006

STATION	Chlorophyll *a*	NH3-N	NO3-N	TP	TSS
ST-1	4.5	ND <0.01	0.03	0.08	2
ST-2	10.5	0.02	0.07	0.04	2
ST-3	9.0	0.01	0.06	0.04	ND <2
ST-4	8.1	ND <0.01	0.07	0.04	6
ST-5	6.2	0.03	0.03	0.03	ND <2
ST-6	9.7	0.04	0.04	0.03	2
ST-7	14.6	0.02	0.1	0.05	3
ST-10	6.0	0.02	0.07	0.03	7
ST-11	15.7	0.01	0.12	0.03	ND <2
ST-2 DEEP					
MEAN	9.4	0.02	0.07	0.04	3.7

HOPATCONG
6/16/2006

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	8	ND <0.01	0.06	0.05	2
ST-2	5.4	ND <0.01	0.05	0.03	ND <2
ST-3	13.9	ND <0.01	0.06	0.03	4
ST-4	4.1	ND <0.01	0.04	0.04	2
ST-5	11.2	ND <0.01	0.03	0.01	ND <2
ST-6	3.5	ND <0.01	0.07	0.02	2
ST-7	5.1	0.01	0.13	0.05	ND <2
ST-10	7.9	ND <0.01	0.12	0.04	3
ST-11	6.5	0.01	0.14	0.05	2
ST-2 DEEP		0.04	0.28	0.02	ND <2
MEAN	7.29	0.01	0.10	0.03	2.50

HOPATCONG
7/25/2006

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	22.7	0.02	0.04	0.06	6
ST-2	11.9	0.02	ND <0.02	0.02	2
ST-3	48.7	0.01	0.07	0.08	12
ST-4	19.5	0.01	ND <0.02	0.03	6
ST-5	20.8	0.01	0.03	0.04	2
ST-6	11.6	0.01	ND <0.02	0.03	4
ST-7	11	0.02	0.08	0.05	ND <2
ST-10	19.4	0.02	0.08	0.06	21
ST-11	12	ND <0.01	0.11	0.07	4
ST-2 DEEP		0.01	ND <0.02	0.02	5
MEAN	19.73	0.02	0.07	0.05	7.13

HOPATCONG 8/22/2006 STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	10	0.03	0.04	ND <0.01	4
ST-2	11.1	0.02	ND <0.02	ND <0.01	ND <2
ST-3	58	0.01	0.04	0.03	9
ST-4	23.1	0.03	ND <0.02	ND <0.01	5
ST-5	19.1	0.05	0.07	ND <0.01	3
ST-6	7.5	0.07	0.02	ND <0.01	ND <2
ST-7	3.2	0.03	0.03	ND <0.01	ND <2
ST-10	9.8	0.03	0.06	ND <0.01	3
ST-11	3.1	0.03	0.04	0.01	ND <2
ST-2 DEEP		0.03	0.05	0.02	2
MEAN	16.10	0.03	0.04	0.02	4.33

HOPATCONG
9/28/2006

STATION	CHL A	NH3-N	NO3-N	TP	TSS
ST-1	9.3	ND <0.01	0.03	0.02	ND <2
ST-2	13	0.02	0.02	0.01	ND <2
ST-3	22.1	0.02	0.05	0.01	2
ST-4	5	0.01	ND <0.02	ND <0.01	ND <2
ST-5	4.6	0.03	ND <0.02	0.01	2
ST-6	6.3	0.03	ND <0.02	ND <0.01	ND <2
ST-7	5.8	0.03	0.04	0.01	ND <2
ST-10	9.4	0.04	0.02	0.01	2
ST-11	7.3	0.04	0.07	ND <0.01	3
ST-2 DEEP		1.4	0.09	0.39	
MEAN	9.20	0.18	0.05	0.07	2.25

Tributary Monitoring Program - 2006

(all measurements in mg/L)

27-Sep-06	SRP	TDP	TP	NO3-N	TSS
#1- Jaynes Brook	0.006	< 0.01	< 0.01	0.04	< 2
#2- Quarry Brook	0.007	< 0.01	0.01	3.3	2
#3- Great Cove	0.008	0.02	0.03	0.82	2
Field Blank	-----	-----	< 0.01	-----	-----
26-Oct-06	**SRP**	**TDP**	**TP**	**NO3-N**	**TSS**
#1- Jaynes Brook	0.004	< 0.01	< 0.01	0.03	< 2
#2- Quarry Brook	0.006	< 0.01	< 0.01	2.6	< 2
#3- Great Cove	0.004	< 0.01	0.01	0.57	3
Duplicate Sample	-----	-----	-----	2.6	-----
Field Blank	-----	-----	-----	< 0.02	-----
1-Nov-06	**SRP**	**TDP**	**TP**	**NO3-N**	**TSS**
#1- Jaynes Brook	0.004	< 0.01	< 0.01	3	3
#2- Quarry Brook	0.003	0.01	0.02	< 0.02	2
#3- Great Cove	0.006	0.01	< 0.01	0.46	< 2
Duplicate Sample	-----	-----	< 0.01	-----	-----
Field Blank	-----	-----	< 0.01	-----	-----
20-Nov-06	**SRP**	**TDP**	**TP**	**NO3-N**	**TSS**
#1- Jaynes Brook	0.002	< 0.01	< 0.01	0.06	< 2
#2- Quarry Brook	0.004	< 0.01	0.01	1.2	< 2
#3- Great Cove	0.006	0.01	0.02	0.83	< 2
Duplicate Sample	-----	-----	0.01	-----	-----
Field Blank	-----	-----	-----	-----	< 2

Pre-Installation Stormwater Monitoring for 319 Projects

(all measurements are in mg/L)

29-Sep-06	SRP	TDP	TP	TSS
ID #1	0.03	0.04	0.06	3
ID #2	0.017	0.02	0.04	< 2
ID #4	0.036	0.04	0.06	<2
Duplicate Sample	-----	-----	-----	2
S9-RB	-----	-----	-----	<2
12-Oct-06	**SRP**	**TDP**	**TP**	**TSS**
ID #1	0.033	0.03	0.04	< 2
ID #2	0.042	0.05	0.07	< 2
ID #4	0.027	0.04	0.05	2
Duplicate Sample	-----	-----	0.04	-----
S9-RB	-----	-----	< 0.01	-----
8-Nov-06	**SRP**	**TDP**	**TP**	**TSS**
ID #1	0.043	0.07	0.09	7
ID #2	0.04	0.07	0.13	33
ID #3	0.029	0.04	0.04	39
ID #4	0.079	0.1	0.1	12
Duplicate Sample	-----	-----	-----	33
S9-RB	-----	-----	-----	< 2
13-Dec-06	**SRP**	**TDP**	**TP**	**TSS**
ID #1	0.079	0.09	0.15	12
ID #2	0.054	0.06	0.14	21
ID #3	0.04	0.05	0.11	21
ID #4	0.011	0.01	0.07	7
Duplicate Sample	-----	-----	0.10	-----
S9-RB	-----	-----	-----	< 2